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Obtainment of Ultrahigh Vacuum with the Aid of Chromium Dispersed by Electron Bombardment

by

G.S.Mikhaylov; G.M.Presnyakova; O.M.Akimovich

It was shown by [1] that metallic chromium dispersed by electron bombardment in high vacuum ($p \sim 10^{-4} - 5 \cdot 10^{-8}$ mm Hg) has an intensive vacating (pumping) effect, close to the vacating effect of titanium, and that the presence of the latter is connected with "self-purification" effect of chromium at the time of dispersion, which is due to the high oxide resistance of chromium (Cr_2O_3) prior to electron bombardment and high temperature. As result os such "self-purification" it becomes possible to evaporate pure chromium from samples, contaminated by oxygen: oxygen in combination with Cr_2O_3 remains on the surface of chromium; evaporized pure chrome and proper vacating effect.

It was considered interesting to continue the investigation of the vacating effect with respect to ultrahigh vacuum ($p < 5 \cdot 10^{-8}$ mm Hg). Certain far reaching preconclusions on the vacating effect of Cr in this vacuum zone, going beyond the previously described by us attempts, had to be made because, first of all, it was not known whether we will reach a chromium oxide dissociation elasticity (always present on dispersed chromium species [1]) at sufficiently high dispersion temperatures (1700-1750°) and in conditions of intensive electron bombardment values, which lie here in the range of pressures $p \sim 10^{-8} - 10^{-10}$ mm Hg at which we have decided to conduct the experiments.

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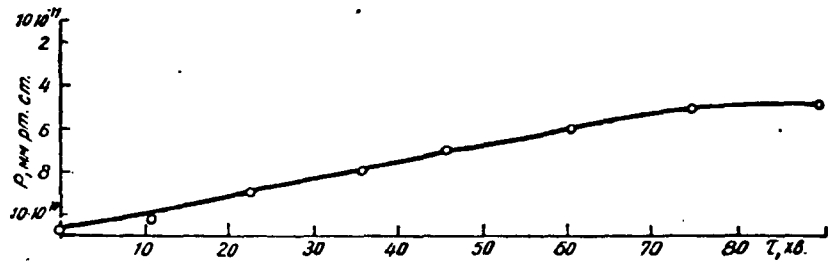
* According to chemical analysis data, the volume of oxygen in the Cr used by us was $1 \cdot 10^{-3}$ weight percentages.

With this purpose in mind we conducted investigations with the use of experimental tubes analogous to the ones described in [1], unsoldered or jointed with the oil fractionation pump MM-40 through a connecting piece which differed from the previously used only by the fact, that they were lacking the device for oxygen filling, and in addition, the sensing element of the ionization manometer was an Alpert type tube. Total volume of each experimental tube was more than 3 liters.

The experimental tubes in all instances were heated for a period of 3 hrs prior to unsoldering or measuring, when vacating with pump MM-40 to $p \sim 10^{-6}$ mm Hg, after which a rigid adjustment was made of all metal components by passing a stream or by electron bombardment. The dispersion of Cr for the purpose of measuring its vacating effect was done by electron bombardments at $V_a \approx 300$ v and $I_a \approx 100$ ma; the walls of tube balloons were cooled by means of a fan. Killing of oil vapors after removal by MM-40 pump was not made.



graph

It was found, that in tubes, jointed with pump MM-40 by a connecting piece, during the dispersion of chromium ny electron bombardments, can easily be obtained a vacuum of $\sim 2\text{-}5 \cdot 10^{-9}$ mm Hg, whileon the part of the oil pump it amounts to $2 \cdot 10^{-6}$ mm H_g. This indicates a sufficiently high rate of vacating, which is developed by Cr at the time of dispersion. Evaluation of the rate of air vacating (pumping) by chromium, made by the method of "two-pressure gages" [2] (instead of a connecting piece in this case was soldered in a narrow pipe line, with an opening diameter d = 4,5 mm and length l = 25 mm), gives a value of $\sim 5 \cdot 10^{2}$ liters/sec at a vacuum of $2 \cdot 10^{-9}$ mm Hg.

In just now unsoldered experimental tubes, in which directly prior to unsoldering from pump, chromium was dispersed, the pressure of the remaining gases was $2\text{-}3\cdot10^{-9}$ mm Hg. By additional dispersion of Cr by electron bombardments already in the unsoldered tube it was possible to drop it within 80-100 min to $\sim 5\cdot10^{-10}$ mm Hg. On the drawing is given an example of vacating with dispersed chromium one of the unsoldered experimental tubes.

In these investigations at pressures of $5\cdot10^{-10} \leq p \leq 5\cdot10^{-8}$ mm Hg on the Cr samples at the time of their dispersion by electron bombardment, just as before [1] were observed concentrations of filiform and chromium oxide Cr_2O_3 crystallites similar to them, which under conditions of our experiments have not been destroyed under the effect of electron bombardment and high temperature.

In this way, the observed by us effect of "self-purification" of chromium allows to use ordinary oxygen contaminated Cr for the obtainment of ultrahigh vacuum (up to $p \approx 5\cdot10^{-10}$ mm Hg) by dispersing same with electron bombardments.

In conclusion express great appreciation to member correspondent of the Academy of Sciences Ukr-SSR O.Ya.Usikov for his interest in the experiment and for valuable council.

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Certain Characteristics of Partial Adsorption of Components of Residual Gases at Very High Vacuum. II .

by

Yu.G.Ptushinskiy; B.O.Chuykov

It is known, that gas adsorption processes, of gases which remain ordinarily in electrovacuum devices, do really affect the vacuum conditions in the instruments as well as the properties of its (their) basic elements, particularly the cathode. This investigation of adsorption of components of residual gases appears to be very important in connection with problems of vacuum technique and cathode electronics. Particular actuality have similar investigations attained recently in connection with broader introduction of ultrahigh vacuum technique into practice of research labs.

The most widely used method of investigating the kinetics of gas adsorption is the so-called flash method [1] the nature of which is based on the registration of pressure rise, caused by rapid heating of the investigated surface to high temperature and the promoted by it desorption of all adsorbed gas molecules.

It appears to be advisable to unite this method of investigating adsorption processes with the mass-spectrometry method. It is apparent that the use of the flash method in such a mass-spectrometric variant will allow to investigate simultaneously the adsorption of all components of natural and artificial mixture of residual gases, to investigate their mutual effect and in this way obtain a greater number of different data.

The first announcements on certain results of applying the flash method in mass spectrometric variant for the purpose of investigating adsorption of components of a natural mixture of residual gases on tungsten have been published earlier [2] In the given report, which is a continuation of [2] are given new data on the kinetics of

adsorption of components of residual gases as well as data on temperature stability of components of residual gas film adsorbed on the surface of tungsten.

Method

A mass-spectrometer of sectorial type with a 60° angle of rotation of the beam of ions was used. It had a sensitivity of 10^{-17} a/mm with glass tube analyzer intended for investigations in conditions of ultra high vacuum[3]. The exhaustion (vacating) of tubes was done, as usually, with repeated rotation (alternation) of heating the glass and internal components. After the vacating job was completed the tube was isolated from the vacuum system with the aid of a tin shutter. The pressure of residual gazes in the tube is ordinarily kept at a level of $2 \cdot 10^{-8}$ mm Hg. It was sometimes necessary to enrich the mixture of residual gases with some kind of component. For this purpose sources of suitable gases have been placed in the tube.

Measurement results

The characteristic of adsorbability of any given component of residual gases can be the relative rise in partial pressure ΔP_m at a flash to background pressure P_m, or equal to its ratio $\frac{\Delta I_m}{I_m}$ (ΔI_m and I_m - increment in ion stream during the flash and background ion stream of given component respectively). In fig.1. are given dependence curves $\frac{\Delta I_m}{I_m}$ for m = 2 (H_2), m = 16 (CH_4) and m = 28 ($CO+N_2$) from the time of adsorption at room temperature. The proper curves for inert gases He and Ar fused with the axis of the abscissas. From analysis of fig.1. is evident that the adsorbability of components of residual gases allows to divide them into three groups.

SEE PAGE 5a FOR FIGURE 1

Fig.1 Dependence on $\frac{\Delta I_m}{I_m}$ upon time of adsorption

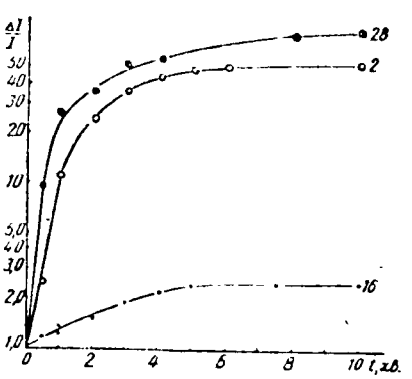

Figure 1.

The first group includes hydrogen, nitrogen and carbon oxide, which adsorbs most actively; group two - methane, which adsorbs much poorer; the third group - inert gases, which practically do not adsorb. According to data in fig.1. it is possible to estimate the relationship between the probabilities of adhesion of various components. Especially, the probability of adhesion of CH_4 molecules appears approximately 25 times less than the probability of adherence of CO or N_2 molecules.

In this way, evaluating the possible effect of atmosphere of residual gases on the properties of investigated surfaces, it is insufficient to know their total (absolute) pressure or even partial pressure of components, but it is necessary to consider the adsorbability of these components, which, as we have seen, can be substantially different. For example, for a typical mixture of residual gases at a total pressure of the order of 10^{-8} mm Hg the rate of adsorption on the surface of tungsten will be the same as the rate of adsorption of an imaginary gas with a 100% probability of adhesion at a pressure of the order of 10^{-10} mm Hg.

Components of residual gases adsorb parallel and are basically independent from each other with respect to their partial pressures, probability of adhesion and total degree of surface filling. Only when working with mixtures, artificially enriched with hydrogen and carbon oxide, did we observe certain signs of slight expulsion of hydrogen from the tungsten surface by carbon oxide.

To explain the effect of liner temperature on the adsorption of components of residual gases experiments will be carried out at various temperatures of the tungsten band, temperatures exceeding 300°K. After high temperature cleaning of the band its temperature was reduced to necessary and a ten minutes exposure was made. Then, as usually, having made the flash the value ΔI_m was measured. Results of these measurements for m = 2, 12, 14, 15, 16 and 28 are given in fig.2. As is evident from the drawing, ΔI_m is characterized by stability, different for various components, temperature zones and then by a gradual drop to zero, which naturally is explained by evapora-

tion. For curves, which correspond to m = 15 and 16 stability is preserved approximately to 400°K, which is, apparently, an indication of the fact, that methane is retained fully on the surface of tungsten until it becomes red hot at that temperature.

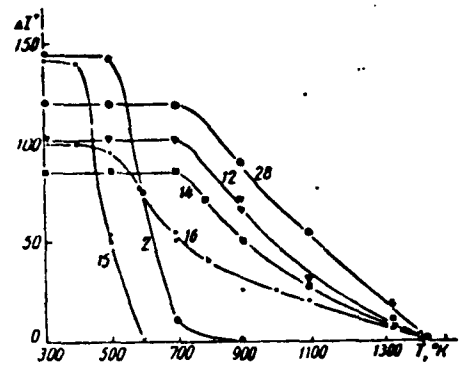

Fig.2. Effect of liner temperature on the adsorption of residual gas components.

○
□
●

Hydrogen (m = 2) is retained fully up to a temperature $T < 500°K$, carbon oxide and nitrogen (m=28) - $T < 700°K$. It isnecessary to keep in mind, that the boundary temperature, at which, e.g. hydrogen is still fully retained on the surface, depends upon the amount of adsorbed hydrogen; in our instance the layer of adsorbed hydrogen is thinner than the monomolecular. Among other things, the identical nature of curve sloping $\Delta I_m(T)$ for m = 12, 14 and 28 indicates, that the curve which corresponds to m = 28 belongs to a CO and N_2 mixture.

Practically total evaporation of methane from the surface of tungsten takes place at $T > 600°K$, hydrogen - at $T > 800°K$, carbon oxide and nitrogen - at $T > 1500°K$.

Somewhat unusual here is the behavior of curve for m = 16: on one hand it sloping begins at $T \approx 400°K$, which is characteristic for methane, on the other hand - it drops to zero only at $T \approx 1400°K$, which is characteristic of carbon oxide. Such behavior of the curve for m = 16 is explained by the fact, that it belongs to the CH_4 and O mixture which is a fragment of CO.

In this way, as is evident from the listed data, for total rectification of tung-

sten surface in conditions of ultrahigh vacuum is necessary that same be heated to a temperature $T > 1500°K$ (at given typical composition of residual gas mixture). It is also especially evident from these data that by maintaining a tungsten surface temperature of the order of 700°K it is possible to do away with the presence on it of methane and hydrogen and to investigate the adsorption of CO and N_2.

In conclusion the authors wish to express thanks to member correspondent of the Academy of Sciences Ukr-SSR N.D.Morgulis for constant attention in the experiment and for councils.

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Submitted July 22, 1961

Effect of Electrostatic Instabilities on the Function of Distribution of the Beam, which Reacts with Plasma in Magnetic Field

by

V.D.Shapiro and V.I.Shevchenko

Instabilities originating during beam/plasma reaction in the magnetic field, have been quite thoroughly investigated in linear approximation [1, 2].

With the rise in amplitude of oscillations, excited by the beam their effect on beam and plasma may become quite recurring, thus leading to a slow change in time of directed rate of the beam and thermal energy of the beam and plasma. Equations, determining change in function of beam or plasma distribution as result of interaction with oscillations in the absence of a magnetic field, were derived by [3-5]. Below this method is applied to the case of plasma, which is in a magnetic field.

We will write the function of electron beam distribution and plasma distribution in the presence of oscillations in form of: $f = f_0(t,v) + f_1(t,r.v)$, where $f_0 = \langle f \rangle$ characterizes the "background" at which oscillations are developing, and f_1 describes oscillations of beam or plasma (Averagings are made with respect to distances, great in comparison with the duration of the oscillations period and by time intervals large in comparison with the period of oscillations). Equations for f_0 can be obtained by averaging the kinetic equation without the integral of twin collisions:

$$\frac{\partial f_0}{\partial t} - \frac{e}{mc}[\vec{v}\vec{H}_0]\frac{\partial f_0}{\partial \vec{v}} - \frac{e}{m} < \vec{E}_1 \frac{\partial f_1}{\partial \vec{v}} > - \frac{e}{mc} < [\vec{v}\vec{H}_1]\frac{\partial f_1}{\partial \vec{v}} > = 0. \qquad (1)$$

Integral of collisions in (1) was omitted, since quite rapid processes are being observed: $\tau_f \ll \tau_0$ (τ_f - time, within which there is a substantial change in f_0; $\frac{1}{\tau_e}$ - frequency of collisions). The obtained formulas will be valid at $t \ll \tau_0$.

For further consideration are important such two assumptions: plasma oscillations are considered linear and the function of distribution f_0 changes with time slowly in comparison with plasma oscillations.

In this report is discussed a case, where plasma oscillations are longitudinal and axially-symmetrical in plane, perpendicular to the magnetic field.

Having written f_1 and E_1 in form of:

$$f_1 = \frac{1}{2}\left\{\sum_{\vec{k}} f_{\vec{k}}(t, \vec{v})\, e^{i(\vec{k}\vec{r} - \omega_{\vec{k}} t)} + \text{к.с.}\right\};$$

$$\vec{E}_1 = \frac{1}{2}\left\{\sum_{\vec{k}} \vec{E}_{\vec{k}}(t)\, e^{i(\vec{k}\vec{r} - \omega_{\vec{k}} t)} + \text{к.с.}\right\} \qquad (2)$$

and utilizing for the connection $f_{\vec{k}}$ with $E_{\vec{k}}$ the formula of linear theory

$$f_{\vec{k}} = \frac{e}{m\omega_H} \exp\{-i\lambda_1 \sin\theta\} \left[\sum_{n=-\infty}^{\infty} \frac{e^{in\theta}}{i(n-\lambda_1)} J_n(\lambda_2) E_z \frac{\partial f_0}{\partial v_z} + \right.$$

$$\left. + \frac{1}{2i}\left(\frac{e^{i(n+1)\theta}}{n+1-\lambda_1} + \frac{e^{i(n-1)\theta}}{n-1-\lambda_1}\right) J_n(\lambda_2) E_\perp \frac{\partial f_0}{\partial v_\perp}\right]; \qquad (3)$$

$$\lambda_2 = \frac{k_\perp v_\perp}{\omega_H}; \quad \lambda_1 = \frac{\omega_{\vec{k}} - k_z v_z}{\omega_H}; \quad \omega_H = \frac{eH_0}{mc};$$

$$\cos\theta = \frac{\vec{k}\vec{H}_0}{kH_0}; \quad \omega_{\vec{k}} = \omega'_{\vec{k}} + i\Omega_{\vec{k}}$$

($\omega_{\vec{k}}$ is designated by dispersion interrelation of linear theory.) we obtain from (1) such equations for f_0:

$$\frac{\partial f_0}{\partial t} = \frac{\partial}{\partial v_i}\left(\alpha_{ik} \frac{\partial f_0}{\partial v_k}\right). \qquad (4)$$

α_{ik} - tensor of diffusion coefficients in space of velocities in the presence of a magnetic field.

In case of instabilities, due to the Vavilov-Cherenkov effect or to the anomalous Doppler effect, the tensor α_{ik} has the form of:

SEE PAGE 10a FOR EQUATION 4'

$$\sigma_{xx} = \sigma_{yy} =$$

$$= \frac{e^2}{4\pi^3 m^2} \int d\vec{k} \, |E_{\vec{k}}^-|^2 \frac{k_\perp^2}{k^2} \sum_{l=-1}^{\infty} \frac{J_l^2(\lambda^2) l^2}{\lambda_2^2} \left(\frac{\delta_{\vec{k}}^-}{(l\omega_H - \omega_{\vec{k}}^{r-} + k_z v_z)^2 + \delta_{\vec{k}}^{2-}} + \frac{\delta_{\vec{k}}^-}{(l\omega_H + \omega_{\vec{k}}^{r-} - k_z v_z)^2 + \delta_{\vec{k}}^{2-}} \right).$$

$$\sigma_{xz} = \sigma_{zx} =$$

$$= \frac{e^2}{4\pi^3 m^2} \int d\vec{k} \, |E_{\vec{k}}^-|^2 \frac{k_\perp^2}{k^2} \frac{k_z v_x}{\omega_H} \sum_{l=-1}^{\infty} \frac{J_l^2(\lambda_2) l}{\lambda_2^2} \left(\frac{\delta_{\vec{k}}^-}{(l\omega_H - \omega_{\vec{k}}^{r-} + k_z v_z)^2 + \delta_{\vec{k}}^{2-}} - \right.$$

$$\left. - \frac{\delta_{\vec{k}}^-}{(l\omega_H + \omega_{\vec{k}}^{r-} - k_z v_z)^2 + \delta_{\vec{k}}^{2-}} \right).$$

$$\sigma_{yz} = \sigma_{zy} = \frac{v_y}{v_x} \sigma_{xz}, \qquad \sigma_{xy} = \sigma_{yx} = 0, \tag{4'}$$

$$\sigma_{zz} = \frac{e^2}{4\pi^3 m^2} \int d\vec{k} \, |E_{\vec{k}}^-|^2 \frac{k_z^2}{k^2} \left[\frac{J_0^2(\lambda_2) \cdot \delta_{\vec{k}}^-}{(\omega_{\vec{k}}^{r-} - k_z v_z)^2 + \delta_{\vec{k}}^{2-}} + \right.$$

$$\left. + \sum_{l=-1}^{\infty} J_l^2(\lambda_2) \left(\frac{\delta_{\vec{k}}^-}{(l\omega_H - \omega_{\vec{k}}^{r-} + k_z v_z)^2 + \delta_{\vec{k}}^{2-}} + \frac{\delta_{\vec{k}}^-}{(l\omega_H + \omega_{\vec{k}}^{r-} - k_z v_z)^2 + \delta_{\vec{k}}^{2-}} \right) \right].$$

In (4) integrations by k_z are carried out in the zone $k_z > 0$. E_k^2 - square of amplitude of electric field of plasma oscillations with a certain k:

$$\frac{d}{dt}|E_k^2| = 2\gamma_k |E_k^2|. \qquad 4'$$

In case of a Vavilov-Cherenkov or anomalous Doppler effects the proton will be irradiated under an acute angle in direction of motion of the particle and for the growing with time oscillations the projection of phase velocity in direction of motion of the beam will always be positive, and it is evident herefrom, that in case of instabilities due to the Vavilov-Cherenkov and anomalous Doppler effects $\omega_{-k}^{\pi} = -\omega_k^{\pi}$ for each type of instability, and that is exactly what we utilized in the derivation of (4).

In this report are considered changes in temperature and rectified velocity "nearly monoenergetic" of the electron beam, which reacts with electron plasma in the magnetic field.

Considering as realized the conditions

$$\frac{k_z^2 v_{T_\parallel}^2}{\omega^2} \sim \frac{v_{T_\parallel}^2}{u^2}, \quad \frac{\omega^2}{\omega_H^2} \ll 1, \quad \frac{k_\perp v_{T_\perp}}{\omega_H} \ll 1, \quad \frac{k_z^2 v_{T_\perp}^2}{\omega_H^2} \ll 1 \qquad (5)$$

($v_{T_\parallel}, v_{T_\perp}$)- thermal velocities of the beam through length and breadth of the magnetic field; u - directed velocity), we will obtain, by solving equation (4), such formulas for longitudinal and lateral temperatures and directed velocity of the beam:

SEE PAGE 11a FOR EQUATION 6

$$T_1 = T_0\left(1+\frac{2m}{T_0}\int_0^t a_{zz}(u)\,d\tau\right) = T_0\left(1+\frac{e^2}{2\pi^3 m T_0}\int_0^t d\tau\int d\vec{k}\,|E_{\vec{k}}|^2\times\right.$$
$$\left.\times\frac{k_z^2}{k^2}\,\frac{\delta_{\vec{k}}}{(\omega'_{\vec{k}}-k_z u)^2+\delta_{\vec{k}}^2}\right).$$

$$T_\perp = T_0\left(1+\frac{2m}{T_0}\int_0^t a_{xx}(u)\,d\tau\right) = T_0\left[1+\frac{e^2}{2\pi^3 m T_0}\int_0^t d\tau\int d\vec{k}\,|E_{\vec{k}}|^2\,\frac{k_\perp^2}{4k^2}\times\right.$$
$$\left.\times\left(\frac{\delta_{\vec{k}}}{(\omega'_{\vec{k}}-k_z u+\omega_H)^2+\delta_{\vec{k}}^2}+\frac{\delta_{\vec{k}}}{(\omega'_{\vec{k}}-k_z u-\omega_H)^2+\delta_{\vec{k}}^2}\right)\right]. \qquad (6)$$

$$u(t) = u_0+\int_0^t\left(\frac{\partial a_{zz}}{\partial u}+\frac{\partial a_{zx}}{\partial v_x}+\frac{\partial a_{zy}}{\partial v_y}\right)d\tau = u_0-\frac{e^2}{2\pi^3 m^2}\int_0^t d\tau\int d\vec{k}\,|E_{\vec{k}}|^2\times$$
$$\times\left\{\frac{k_z^3}{k^2}\,\frac{\delta_{\vec{k}}\,(k_z u-\omega'_{\vec{k}})}{[(\omega'_{\vec{k}}-k_z u)^2+\delta_{\vec{k}}^2]^2}+\frac{k_\perp^2}{4k^2}\,\frac{k_z}{\omega_H}\left(\frac{\delta_{\vec{k}}}{(\omega'_{\vec{k}}-k_z u+\omega_H)^2+\delta_{\vec{k}}^2}-\right.\right.$$
$$\left.\left.-\frac{\delta_{\vec{k}}}{(\omega'_{\vec{k}}-k_z u-\omega_H)^2+\delta_{\vec{k}}^2}\right)\right\}.$$

Considering, that the amplitudes of fields and plasma at t = 0 in case of longitudinal oscillations [6] have the nature of thermal fluctuations

$$|E_k^0|^2 = \frac{4\pi T_e}{1 + k^2\lambda_D^2} \quad \left(\lambda_D^2 = \frac{T_e}{4\pi N_e e^2}\right). \qquad (6a)$$

and calculating the integrals in (6) by the transformation method, we will obtain for sufficiently rarefied plasma ($\omega_H \gg$ omega, omega $= \sqrt{4\pi N_0 e^2}$);

$$\frac{(\Delta T)_\perp}{T_e} = \frac{\sqrt{2}}{12\pi}\frac{\omega_H^3}{N_1 u^3}\frac{e^3 D^3}{\tau};$$

$$\frac{(\Delta T)_1}{T_e} \sim \frac{\Omega^2}{\omega_H^2}\frac{N_1}{N_e}\frac{(\Delta T)_\perp}{T_e} \ll \frac{(\Delta T)_\perp}{T_e}; \quad |mu\delta u| \simeq (\Delta T)_\perp \qquad (7)$$

In cas of instability, due to anomalous Doppler effect, and

$$\frac{(\Delta T)_1}{T_e} = 5\cdot 10^{-3}\frac{\Omega^2}{N_1 u^3}\frac{e^3 e^{\beta_e^2}}{\tau^{3/2}}; \quad \frac{(\Delta T)_\perp}{T_e} \sim \frac{\Omega^2}{\omega_H^2}\left(\frac{N_1}{N_e}\right)^{1/3}\frac{1}{\tau}\frac{(\Delta T)_1}{T_e} \ll \frac{(\Delta T)_1}{T_e};$$

$$|mu\delta u| \simeq \frac{1}{2^{1/3}}\left(\frac{N_e}{N_1}\right)^{1/3}(\Delta T)_1 \gg (\Delta T)_1 \qquad (7')$$

in case of instability, due to Vavilov-Cherenkov effect. In formulas (7) and (7') γ = omegat, β_D = insert eq.(8)...page 86, N_0 - density of plasma, N_1 density of beam, $N_1 \ll N_0$. During the derivation of these formulas it was assumed that $\beta_D\gamma \ll 1$ and $\beta_e\gamma \gg 1$. In addition, they are valid for $t < t_q$, where t_q - time, within which one of the conditions (5) or condition $\delta u \ll u$ is disrupted.

Solution of equation (4), derivation of formula (7) and (7'), as well as examination of instability, due to normal Doppler effects, which originates during the reaction with plasma of a beam of excited oscillators, will be discussed in a special report.

The authors are greatful to Ya.B.Faynberg for the specified subject and constant interest in the investigation, to O.I.Akhiyezer; G.Ya.Lyubarskiy, K.M.Stepanov for analyzing the results of the investigation.

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